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**Efficiency of sports betting markets: A chronological review and its
potential use for entrepreneurship**

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Dissertation

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Dedico este trabalho a todos nós:

*comunidade que pratica o trading em mercados de apostas desportivas,
comunidade que estuda minuciosamente o mercado e dele retira valor,
comunidade verdadeiramente empreendedora cujo sucesso não é fruto da sorte e do acaso.*

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Abstract

The sports betting markets are a central topic of research for several decades, and market efficiency is a matter of primary importance in this field. However, the link between sports betting markets and entrepreneurship is clearly undeveloped in the literature.

Thus, the primary objective of this work is to provide an encompassing literature review, in a chronological array, on the online sports betting markets, focused on market efficiency issues. It also explores the personality and psychological profile of entrepreneurs and discusses to what extent investing on sports betting markets can be considered as an opportunity to run entrepreneurial activities, both for bettors, bookmakers and related third parties.

To address this issue, we examined the market efficiency, aggregating the conclusions of 28 published studies using meta-analysis. Results showed that there is no sufficiently statistical evidence to reinforce neither market efficiency nor market inefficiency hypothesis (on the scale efficiency (-1) / inefficiency (+1), an average of 0.373 and $p>0.3$). However, biases were found, particularly the favorite-longshot bias, suggesting that some forms of market inefficiency persist and, probably, can be explored. The literature review also shows that the link between sports betting markets and entrepreneurial activities are yet understudied.

Since there is little literature that addresses entrepreneurship in sports betting markets, this work can bring valuable insights to the development of new paths that can be drawn to run entrepreneurial activities and business opportunities, by all the agents involved in this sector.

Keywords: betting markets; market efficiency; entrepreneurship; entrepreneurs.

JEL-Codes: G14 Information and Market Efficiency; L26 Entrepreneurship

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1 Introduction

The internet has totally revolutionized the sports betting markets mainly because it decreased transaction costs dramatically, enabled a reduction in the time between the event and the close of the market and increased the market geographically. (Davies et al., 2005). Online betting markets are becoming a global industry and at the forefront of this revolution is the appearance of betting exchanges that totally changed the dynamics of this market (Tsirimpas and Knottenbelt, 2011).

Until 2000, the markets were monopolized by bookmakers (Franck et al., 2010). These agents were able to establish a price (as an odd format) to pay the probability of a particular event happening. That price reflects the bookmaker's expectation regarding the event with a sufficient margin to enable it to have a positive expected profit and little risk of bankruptcy. Then, the bettors decide to bet or not based on the perception of risk about that price (Levitt, 2004). In fact, due to the detail that the bookmakers are profit maximizers and that transaction costs are high, only a slight fraction of bettors could get long-term profit consistency (Newall, 2015). Furthermore, these market makers also explore the fact that bettors are usually risk lovers and they also explore some complex mechanisms based on bettors' biases that are already well studied in the literature (e.g. Smith and Williams, 2010; d'Astous and Di Gaspero, 2015).

With the development of internet-based betting exchanges, including Betfair,¹ it became possible for the bettors to negotiate directly between themselves, increasing the market dimension. For that reason, the study of the efficiency of betting markets has attracted growing interest (Stekler et al., 2010; Direr, 2013).

By definition, in an efficient financial market, all the information about an asset is properly incorporated into its price and so the price of that asset is the true estimation of its value (Fama, 1970). In turn, in an efficient betting market, the ratio price/premium quantifies the probability of being a successful bet.

In fact, sports betting markets are somewhat similar to exchange financial markets since both are based on future and uncertain outcomes, they have several participants contributing with their insights based on the available information (Tsirimpas and

¹ www.betfair.com, accessed on 16th November 2015

Knottenbelt, 2011; Woodland and Woodland, 1994) and therefore, it can provide important insights that extend to these markets (Woodland and Woodland, 2015; Berkowitz et al., 2015).

This phenomenon naturally also deserved the attention of government authorities because of its economic and financial impact, for different reasons such as the sovereign opportunity to create new businesses but also due to the threat of gambling and addictive problems (Paton et al., 2009). The fact that, by 2011, Betfair exchange had more than five million transactions every day, more than all of the European stock exchanges combined, is evidence of the growing economic importance of the betting industry (Tsirimpas and Knottenbelt, 2011).

There is already some information about sports betting markets in the literature (Sauer, 2005). The great majority of the studies available are covering topics such as the behavioral patterns and social implications (e.g., D'Astous and Di Gaspero, 2015), gambling problems (e.g., Bouju et al., 2011; Gray et al., 2012) market efficiency (e.g. Docherty and Easton, 2012), market manipulation (e.g., Putniņš, 2012) and public policies (e.g., Paton et al., 2010), but such literature is diffused and no solid review exists on the broad topic.

Additionally, the existing literature overemphasizes the negative side of this activity, by focusing mainly on issues about gambling problems and its consequences. Indeed, a bibliometric exercise shows that 43% of the literature available is focused on gambling problems while remaining critical issues are still poorly addressed.²

But, should these markets, in general, be actually considered a threat and a source of potential gambling related problems? As Krueger et al. (2000) stated, entrepreneurship is based on taking risks, and an entrepreneur tends to focus more on opportunities than threats. As mentioned above, the emergence of betting exchanges enabled person-to-person betting and created new market dynamics and trading style activities similar to other financial markets, which attracted professional traders (Laffey, 2005).

However, this link between sports betting markets and entrepreneurship is clearly undeveloped in the literature. In fact, a bibliometric exercise shows that there are no

² The search was made in Scopus on 24th October 2015, with article title, abstract and keyword “sports betting” searched in Social Sciences and Humanities.

reliable results and just two of them are addressing the link between sports betting and entrepreneurship.³

Thus, the aim of the present dissertation is to provide an encompassing literature review on the online sports betting markets, focused on market efficiency issues. It is also an objective of this study to explore the personality and psychological profile of entrepreneurs and discuss to what extent sports betting markets can be considered as an opportunity to run entrepreneurial activities.

The present dissertation is organized as follows. In Section 2, a brief historical contextualization will be given on the emergence of sports betting markets and the way they evolved over time to become the huge industry that they are today. The current major forms of betting will be categorized and, in order to offer a broader approach on the subject, the current literature evidence will be briefly summarized regarding some hot topics that, although they are not the core of this dissertation, it makes sense that they be briefly addressed, such as gambling problems and behavioral issues, market manipulation and public policies. In Section 3, in a chronological array, the literature evidence about market efficiency in sports betting markets will be discussed. In Section 4, the concept of entrepreneurship will be defined, namely what is the personality/psychological profile of an entrepreneur. Section 5 details all the methodological considerations and Section 6 presents summary statistics about the overall studies and shows the results of the meta-analysis. Finally, in Section 7, the discussion and main conclusions will be focused on the results of this literature review and the possible link with entrepreneurial activities: the aim of this chapter is to discuss the existence or not of market inefficiencies and summarize the main findings of this review, discuss to what extent do they represent entrepreneurship opportunities and put all these findings in perspective.

³ The search was made in Scopus on 15th December 2015, with article title, abstract and keywords “entrepreneurship” and “betting” searched in Social Sciences and Humanities.

2 Sports betting markets

Betting on sporting events is an old practice. In the Roman Empire, the Circus Maximus was one of the many racetracks where crowds made their bets. Similarly, betting on foot races and ball games was also a common practice among indigenous peoples of North America (Sauer, 1998).

Since the end of 1st World War, the world's population started to expand their leisure spending and start to diversify these forms of entertainment, in particular, betting in different sports like horse races, greyhounds and soccer (Huggins, 2007). After 1918, betting became the second largest leisure activity in the UK and between 1920 and 1938, the total amount spent in betting rose from £63 million to over than £221 million.

As the name implies, it is understood as prediction markets, any market whose dynamics are based on the prediction of results (Figure 1). In this kind of markets is assumed that there is a set of information about an upcoming event that will influence the opinion of bettors and bookmakers in different perspectives (Paton et al., 2010). According to the author, this dissemblance, in the way two parts analyze the same event, is the engine to run these markets.

Since those early years till today, the world witnessed a large increase in prediction market's interest, which included casinos, sports betting, and financial instruments, raising important issues as regulation of these markets, market efficiency, economic implications and public policies to be adopted by governments and public entities (Paton et al., 2010).



Figure 1 Global Prediction Market Segments

2.1 Bookmakers

Bets placed through a bookmaker are the most popular system in this industry. In this system, the bookmakers are the entity that sets the prices in the market. For each event (and for each market within each event) the bookmaker defines an odd, leaving the decision of betting or not in the bettor's side (Levitt, 2004).

In theory, if the odds of an event precisely reflect the probability of that event occurs, then the profit margin of the bookmaker will be equal to the commission charged on the costumers. (Newall, 2015)

The key factor in bookmaker's activity is in its prediction accuracy which is directly related to its behavior in the price setting. Each bookmaker prediction algorithm is unique and unknown, but it also includes the bettor's decisions.

Additionally, what the bookmakers do to increase their profits is to "balance his book" (Franck et al., 2010). They manage the price-setting process to attract equal betting volumes on each side of the possible outcomes. In this scenario, the bookmaker can pay winner's bet with loser's stakes and profit the remaining amount, whatever the outcome of the event (Levitt, 2004).

Assuming a match between two teams, A and B, where the win probability of A is " p ", the odd of A victory (OA) equals to " $1/p$ " and the odd of B victory B (OB) equals to " $1/(1-p)$ ". For instance, if " p " is 5%, then OA and OB must be 20 and 1.053, respectively. The bookmaker, not knowing " p ", can initially assume that it is 50%, making OA and OB equal to 2. Now, the bookmaker will accept bets from bettors with different degrees of information, where the probability assumed by each bettor (p_i) is taken from a distribution with mean " p " and standard deviation " sd ". Now the bookmaker will have a Bayesian algorithm that will adjust " p " according to the betting pool: more money bet on the A victory will increase " p " (and decrease OA) and vice versa. Thus, assuming " p " as the average of all bets, the accuracy error decreases with the square root of the number of bets placed.

2.2 Betting Exchanges – the emergence of Betfair

In 2000, through a web-based venture, person-to-person (P2P) betting model opened the door to a major revolution in the industry of sports betting (Laffey, 2005). Since its launching, Betfair - a betting exchange - has been in the leading of the market share

with a very few number of competitors fighting for a tiny market-share (Koning and Van Velzen, 2009). As Davies et al. (2009: 533) stated, “at the beginning of the 21st century, a new financial exchange has emerged in London. Betfair is a financial exchange for knowledge and opinions on sporting, political and other events.”

Through this real radical innovation, people around the world were allowed to bet with each other, through websites, cutting out with bookmakers (Mainelli and Dibb, 2004). Through a betting exchange, it became possible to individuals, together via the internet, to trade shares among themselves, whose shares are, in the case of betting exchanges, bets on the outcome of a future event (Laffey, 2005). When the result of an event is revealed, each share receives a payoff. Thus, in a betting exchange, each participant analyses the available information about an event and individually contributes with his knowledge. The sports betting markets then represent the aggregation of all knowledge and information of its participants (Spann and Skiera, 2003).

The betting exchange has offered a wide range of new dynamics in this market, making somewhat similar to the stock exchange (Franck et al., 2010). In a broadly way, Betfair's value proposition is to offer a market where bets can be placed. The key is that this betting exchanges put technology in the hands of the punters. To occur a transaction in this market, it is necessary that a punter place a bet at a given price (in odd format) and other punter lay him. This active role in price formation is the big novelty because until then, this process had been the exclusive preserve of bookmakers (Mainelli and Dibb, 2004).

As a betting exchange, the income comes from a small percentage commission on the player's net winning on the event, so, the greater liquidity of an event, the bigger profit Betfair will generate.

The emergence of Betfair is a classic case of a model that is only feasible thanks to the synergy created by five technology-related forces: Moore's law, Metcalfe's law, the flock of birds phenomenon, the fish tank phenomenon and the Coasian economics.

a) Moore's Law

According to Moore's law, the number of transistors of the chips has a 100% increase in the same value every period of 18 months, so the power of computers is ever faster and cheaper (Chien and Karamcheti, 2013).

Taking into account the millions of instant transactions that are made on Betfair each day, it is safe to assume that, if the effects of Moore's Law did not exist, it would be impossible to manage and store all this information with the computing power that existed a few years ago (Davies et al., 2005).

b) Metcalfe's Law

According to Metcalfe's law, the value and usefulness of a network equal the square of the number of users. The more people use a network, the more valuable the network becomes and more users will be attracted (Getov, 2013).

This law explains much of the success of Betfair. This type of markets is only possible if there is sufficient liquidity to let the law of supply/demand flow. Without this effect, it would be impossible for a punter to find on the market another punter who wanted to lay his bet (Davies et al., 2005).

By the way, this effect is a high market entry barrier to competitors because, even assuming that the competitors offer a better service, it is impossible to operate an exchange without liquidity (Mainelli and Dibb, 2004).

c) The Flock of Birds Phenomenon

One of the features of some of the latest communication technologies is that any particular authority does not control their dynamics and the network seems to be the focus of power itself. Because of the similarity with what happens to the flocks of birds that have no "head bird", some authors call it "the flock of bird's phenomenon" (Davies et al., 2005).

This phenomenon is also visible in betting exchanges. Betfair operates online, and none of their users have a privileged position towards the rest of the community. Each user has the same visibility and ability to perform in the betting exchange.

d) The Fish Tank Phenomenon

With the advent of the internet, nowadays, everyone can build a website and be seen by the world. It means that, with this ability, individuals have the power to create inputs that can beat the doings of bigger and well-established companies – that is what is called the "fish tank phenomenon" (Morris et al., 2001).

When Andrew Black invented Betfair⁴ he was changing all sports betting markets. It was a market with large established incumbents, but this change in the way bets could be placed totally revolutionized this industry and the big bookmakers had no capacity of dealing with it.

e) The Coasian economics

Ronald Coase introduced the notion of transaction costs, considering that they represent a set of economic inefficiencies that should be added to the price of a product or service (learning costs, searching costs, monitoring costs, contracting costs, etc.) (Ricketts, 2014). He also stated that these inefficiencies might be, in certain circumstances, corrected and internalized by negotiation between affected parties, without the intervention of a regulator.

Davies et al. (2005: 537) stated that Betfair is a fine example of Coase's theory because "traditional bookmakers need to be well informed (studying horse racing and sporting events carefully) in order to make odds, and need to monitor market changes constantly in order to avoid being taken advantage of, or of being over-exposed. Betfair just provides the platform for many individuals to do this for themselves. These people do not have to rent space or equipment, advertise, or employ staff."

Since people have different expectations regarding the same event, the reduction of transaction costs opened up the possibility to an industry that allows people to exchange in a competitive market these own expectations while improving their satisfaction.

2.3 Gambling: Cognitive Problems and Behavioral Issues

The bibliometric exercise reported in this document, clearly shows that a large amount of research was done in the context of the gambling problem paradigm. Gordon et al. (2015) conducted a recent study about the concept of lifestyle consumption community in Australia and the link with gambling problems. Another study with students in Zagreb, Croatia, examined patterns of sports betting among them and their irrational beliefs, motivations and experiences (Dodig et al., 2015). The way gambling can become in a behavioral dysfunction and how it may lead to harmful consequences for both the individual and the society was also a topic of research (Bouju et al., 2011; Gray et al., 2012).

⁴ In <http://corporate.betfair.com/about-us/betfair-facts.aspx>, accessed 16th November 2015

But in fact, gambling research can be approached from another perspective. Gambling can be seen as a reasoned activity and so, from a research point of view, it is important to understand the decision-making process of people who performs in the market (D'Astous and Di Gaspero, 2015). The influence of bettor's sentiment in the decision making process had already been studied (Avery and Chevalier, 1999). Xu and Harvey (2014) made significant contributions about the gambler's fallacy – the theory in which people who win is more likely to win again, and those who lose are more likely to lose again. In this context, the way bettors make decisions is highly relevant to understand bettor's patterns of thinking and behavior.

2.4 Market Manipulation and Public Policies

The different kinds of market manipulation in stock markets are well documented in the literature (Putniņš, 2012). Similarly, match fixing in sports events that are followed by a betting market seems to be a growing phenomenon (Forrest, 2012). Scandals like the Calciopoli cases, in Italy's professional soccer league, are well described in literature (Buraimo et al., 2012). In his paper, Brown (2015) uncovered interesting findings of this issue. According to the author, there are traders with an advantage due to access to private and inside information. Besides this ones, there are some other studies whose concern is to understand in what extent this is a threat to sports (Bag and Saha, 2011).

Because of this increase in cases of corruption and manipulation of sports betting markets, it becomes evident the need to adopt public policies capable of conveniently regulate the market and prevent this type of crime (Paton et al., 2010).

3 Market Efficiency

One of the central issues of the financial market analysis is market efficiency. The study of this issue aims to realize to what extent the relevant information about an asset is properly incorporated into its price. It means that, in an efficient market, a price of an asset is the true estimation of its value (Gray et al., 2005).

There is an extensive literature on testing the efficiency of markets, mostly in financial markets. If we go back in the timeline, it is possible to find in the literature, Louis Bachelier findings in the early twentieth century and its tests on the efficiency of markets by analyzing the behavior of the market asset prices (Courtault et al., 2000).

Later, on the 60's, several authors evaluated, for example, the price response of assets when firms announce financial events such as stock splits, company mergers, release of firm results, income statements and money supply events (Ball and Brown, 1968; Beaver, 1968; Fama et al, 1969; Waud, 1970).

Particularly, this phenomenon was widely studied by Fama (1965, 1970, 1998) who called it the hypothesis of efficient markets according to which the value of a financial asset incorporates, immediately and thoroughly, all the relevant information about it. All the studies developed by Fama on the hypothesis of market efficiency would contribute significantly to the literature so that this theory remains firmly associated with the author.

Fama (1970) suggested and popularized the three degrees of market efficiency, and this classification was made according to the information that is reflected in the value of an asset: a market with a weak form efficiency, the price of an asset reflects all information available on previous price history. On a different level, a market is characterized with semi-strong efficiency when the price of an asset is continuously and completely updated according to the public information available. Finally, markets with strong form efficiency are those in which prices should always reflect all existing information, including information that is not public. There is no attempt here to explain with detail this topic but instead, introduce some of the main themes about market efficiency in financial markets in order apply them to the sports betting markets.

The market efficiency is not only a matter of central analysis in the financial markets but also in the sports betting markets. In fact, some peculiarities concerning the

dynamics of sports betting markets make them very attractive objects of study in this field (Williams, 1999). In fact, Thaler and Ziemba (1988) were one of the first researchers to argue that the sports betting markets seem to be better suited to study issues related to efficiency, compared to the financial markets. Gray and Gray (1997: 1725) also consider that sports betting market are the “ideal arena for testing market efficiency” because financial markets never reveal the real value of an asset. Williams (1999) corroborates this opinion stating that, apart from the existence of a sufficiently high number of bettors with several sets of information about that asset, these markets still have a particular property which highlights them from the other financial markets: each asset (or bet) have a well-defined termination point (winning or losing the bet, at the end of the event), from which it is possible to know the exact value of that asset and that information makes the study of market efficiency less complex.

The existence of this well-defined bet termination point, seems also to arouse great interest, since it allows the development and research of empirical techniques to deal with the typical problems of the uncertainty of future events (Williams, 1999) and mainly because if systematic biases exist in these markets, it is possible to formulate betting strategies to earn consistent profits, and therefore, show evidence of market inefficiency (Gray et al., 2005). Merton (1987: 485) stated that “the expected duration between the creation of this investment opportunity and its elimination by rational investor actions in the market place can be considerable.”

3.1 The beginnings of the study of efficiency in sports betting markets (before 1990)

Early researches on sports betting markets based on laboratory experiments suggested that, in situations of uncertainty, the events most likely to occur were underbet and low probability events were overbet (Preston and Baratta, 1948). To test this betting behavior under a natural environment, researchers achieved the first findings in the racetrack markets (horse racing). At that time, the racetrack market was the only one studied and the academic community wasn't interested in these markets per se, but rather the information available in these studies that could be extended to financial markets.

Husch et al. (1981) show in their study a summary of the existing literature at the date (*Table 1*) which confirms the existence of strong biases, evidencing the tendency for

bettors to underbet the favorites and overbet the longshots, in line with Preston and Baratta (1948) findings.

Table 1 Rates of return on bets to win by grouped odds (adapted from Husch et al., 1981)

Study	Midpoint of grouped odds							
	0.75	1.25	2.5	5.0	7.5	10.0	15.0	33.0
Griffith (1949)	8.0	4.9	3.1	-3.1	-34.6 ^a	-34.1 ^a	-10.5	-65.5 ^a
McClothin (1956)	8.0 ^b	8.0 ^a	8.0 ^a	-0.8	-4.6	-7.0 ^b	-9.7	-11.0
Fabricant (1965)	11.1 ^a	9.0 ^a	4.6 ^a	-1.4	-3.3	-3.7	-8.1	-39.5 ^a
Weitzman (1965)	9.0 ^a	3.2	6.8 ^a	-1.3	-4.2	-5.1	-8.2 ^b	-18.0 ^a
Seligman (1975)	14.0	4.0	-1.0	1.0	-2.0	-4.0	-7.8	-24.2
Snyder (1978)	5.5	5.5	4.0	-1.2	3.4	2.9	2.4	-15.8

^a Significantly different from zero at 1% level or better

^b Significantly different from zero at 5% level or better

Also, Ali (1977) analyzed the market of horse racing for five years, with a dataset consisted of 20247 races from three tracks and horses were grouped according to the degree of favoritism attributed by the market. To measure this, he called objective probability the proportion of occasions a horse wins a race in an infinite number of times and he called subjective probability the bettors' opinion reflected in the proportion of the win pool that is bet on a horse. Results showed that the difference between objective and subjective probabilities (expressed in ratios to the respective standard errors) are statistically significant in groups 1, 4, 5, 6, 7 and 8 (-10.29, 3.45, 3.49, 3.01, 5.80 and 6.20 respectively). It was also shown that horses with a high objective probability of winning are underbet and horses with low objective probability of winning are overbet, again in accord with Preston and Baratta (1948) findings. The author also suggested that this pattern can be due to a risk-loving bettor's behavior.

By the time, only the "win" market for racetrack betting had been studied. However, participants were able to bet not only on the "win" market but also on "place" and "show" markets. So, a "place" bet has a positive return if the horse finishes first or second position and "show" bet realizes a positive return if the horse is first, second or third. Hausch et al. (1981) were pioneers in this field and proposed to study the efficiency of "place" and "show" markets. The authors (1981: 1435) adopted the

definition of weak-form definition, considering that “the market is weakly-efficient if no individual can earn positive profits using trading rules based on historical price formation”. Two datasets were used in this study: the first included all bets placed in the 627 races in the 1973-1974 winter season at Santa Anita Racetrack; the second dataset included all bets placed in the 1065 races in the 1978 summer season at Exhibition Park. In this study, the authors developed a sophisticated model indicating not only the horse whose bets should be made but also the amount of each bet according to the bettor preferences and wealth levels. The model implementation produced a return of 22.9%, but an important question arose: should the results be attributed to an inefficiency in the market or could they be obtained by mere chance? To clarify this question, the reliability of results was tested by an anonymous referee and significant inefficiencies in the “place” and “show” markets were confirmed.

Later, Asch et al. (1982), in a study developed during the 1978 racing season at Atlantic City Race Course, which included 729 races and 5805 horses, proposed to examine two central questions: are market odds a good predictor of the outcome of a race? Are bettors overbetting underdog horses and underbetting favorite horses, as suggested by Ali (1977)? The results showed that, as was found by Ali (1977), the betting odds have a good forecasting accuracy since the first favored groups are the ones with the higher objective probability of winning. However, and again in line with Ali (1977) findings, evidence of market inefficiency was found in three groups: differences between objective and subjective probabilities (also expressed in ratios to the respective standard errors) are statistically significant at 0.05 level in first favorites (-2.119), third favorites (-1.972) and ninth favorites (2.095). Again, the favorites are underbet and the underdogs tend to be overbet.

3.2 Market efficiency evidence before betting exchanges appearance (1990-2000)

As previously seen, the literature at the date was entirely focused on racetrack betting markets, and so, the markets for other sports were relatively ignored in previous research. There were, until then, a well-documented evidence of some inefficiencies, specifically the tendency of bettors to overbet underdogs and underbet favorites, the so-called favorite-longshot bias (e.g. Ali, 1977; Hausch et al., 1981; Asch et al., 1982).

The study methodology adopted by Golec and Tamarkin (1991) introduced an innovation in the study of sports betting markets. According to the authors, so far,

previous research was based on simple regression and economic tests that were not able to accurately assess market efficiency issues. In this study, the authors make a detailed comparative analysis of the methods used to date and approaches employed in this study. In fact, and to date, several authors have been suggesting that this type of testing had a very little power to reject the market efficiency hypothesis due to their lack of specificity (e.g. Zuber et al., 1985; Gandar et al., 1988).

The dataset of this study included the regular season and playoffs football games from 1973 to 1987 in the NFL and college league, making a total of 3244 NFL games and 6514 college league games, which were analyzed separately.

The results showed that bettors underestimated the power of home and underdog teams systematically during the mentioned period. It was also clearly demonstrated that betting the underdog teams in the NFL was the most profitable strategy, with a statistically significant winning percentage of 55.6%, although profit potential depends on the transaction costs. The college league betting market didn't exhibit any significant inefficiency.

Also Woodland and Woodland (1994) considered that the racetrack betting markets had some disadvantages for bettors when compared to other sports markets, particularly baseball. So, they focused on the comparison of these two markets, specifically on the issue of market efficiency and if the favorite-longshot bias extends to baseball betting markets. For that, a dataset of 24603 games was analyzed, belonging to Major League Baseball (MLB), the major league in the United States of America, for the 1979 to 1989 seasons. The authors tested the market efficiency through the application of some strategies that were formulated based on historical price information.

The results of this study led to two conclusions: first, the tests showed no evidence of inefficiencies in the market, since tests for individual betting lines showed no significant differences between objective and subjective win probabilities (F-statistic of 0.474 and corresponding probability value of 0.628); second, the results suggested the presence of a reverse bias in the baseball market, this is, bettors tend to overbet the favorites, rather than the underdogs, the opposite of what happens in racetrack betting markets.

According to Dare and MacDonald (1996), to date, many researchers had investigated market efficiency issues without considering important characteristics of the game which could lead to a misrepresentation of the results and conclusions of these studies.

In most games, there is a favorite team to win and another that is considered the underdog. Simultaneously, in each game, one team is playing on their field, and the other is the visiting team. These two characteristics are closely related and cannot be analyzed independently. Dare and MacDonald (1996) emphasize this interdependence stating that most games can involve either a home favorite team against an away underdog team or a home underdog team against an away favorite team. These two characteristics seem to be a source of some inefficiencies in the market. However, they have been investigated separately, which can lead to biased findings of market inefficiency.

To bridge this gap, Dare and MacDonald (1996) presented a regression model that considered the interdependence of the favorite-underdog and home-away binomials. This model was applied to two samples separately: the first consisted of 3164 NFL games played between 1980 and 1993; the second consisted of 6685 college football games played between 1981 and 1993. The results showed no evidence of market inefficiencies. Also, the authors showed that previous researchers who studied only one of the characteristics could have biases in their conclusions.

In 1997, Gray and Gray (1997), explored a probit model to test the efficiency of sports markets. The authors considered that, until then, only methodologies with little sensitivity to extreme outliers were made, making it difficult to interpret the results. In contrast, the probit model developed by them applied a filter that selected the most likely to be won bets, based on the prior information available about the games. The aim of this study was to test the efficiency of the National Football League betting market (NFL) and exploit these biases to formulate trading strategies to generate consistent earnings. The sample was composed by the outcomes of a total of 4219 games played between 1976 and 1994 in the NFL. The results revealed that betting just on the teams predicted by the probit model generated a 6.93% profit, with statistical significance ($p = 0.013$). The results suggest that people tend to underestimate home underdog teams (no favorite teams playing on their field) showing the presence of the so-called “home underdog bias”. However, the authors warn of the fact that this market inefficiency is quite attenuated in the last seasons. In this sense, they argue that should be made in the future, new studies to improve the probit model and see if it remains in this market efficiency.

3.3 Market efficiency evidence after betting exchanges appearance (2000-2015)

As previously stated, the emergence of betting exchanges, completely revolutionized the dynamics of sports betting markets (Laffey, 2005; Davies et al., 2009). With the advent of betting exchanges it became possible to obtain high-frequency data relating to bets transacted during the games. This data has opened doors to new methodologies to clarify the study of the sports betting market, including the topic of market efficiency (Croxsom and Reade, 2014).

To update the results of Woodland and Woodland (1994) and see if the reverse longshot-favorite bias persisted, Woodland and Woodland (2003) developed a research again in this baseball market. The updated dataset included the games held during the 1990 to 1999 seasons, making a total of 20829 games in the MLB. The combined dataset consisted of 44675 matches. The results showed that similar to what happened in the study of Woodland and Woodland (1994), bettors still overbet favorite teams and underbet underdog teams. However, the authors state that the presence of this bias does not represent a market inefficiency: the p-value decreased from 0.0097 (in the original study) to 0.037, but efficiency is only rejected with a p-value of 0.002, according to the regression analysis.

Also Dare and Holland (2004) complied with the suggestions of Gray and Gray (1997) on further investigations and decided to modify the previous research methods and test a new model consolidated in the same NFL betting market during the 1995 to 1999 NFL seasons. To analyze that betting strategy, the authors estimated the model, they forecasted the game outcomes and then the profits produced by that procedure were determined. The results renewed the presence of a bias favoring home underdog teams but with no strong enough evidence to reject the hypothesis of efficient markets. The authors warn of the fact that this bias is not consistent from season to season and there is a high risk of adopting a kind of "all or nothing" strategy, leading to bankruptcy. For these reasons, the potential profits generated by bias favoring home underdog teams seem to be too small to be explored, in contrast with Gray and Gray (1997) findings.

Another interesting market to study efficiency hypothesis is the totals market and a study developed by Paul and Weinbach (2005) showed that market efficiency could be rejected. The totals markets is a market where bettors can bet on the total number of points scored by both teams in a given game. The bookmaker posts a set totals numbers and assigns an odd to the under (betting that the total of points scored is lower than the

posted number) and to the over (betting that the total of points scored is higher than the posted number) for each number posted.

The starting premise consists in the fact that bettors are overrating the total points scored by high-scoring teams. Apparently, in games between high-scoring teams, most bettors prefer to bet the over and thus, make the bookmaker adjust the “under” odds to higher values. The aim of the authors is to test whether a strategy based on "betting the under" can be sufficiently profitable to reject market efficiency hypothesis.

Later, the authors decided to verify the presence of this inefficiency in two football leagues: the NCAA college football and the Arena Football League (Paul and Weinbach, 2005). The study sample included the NCAA games played between 1999 and 2003 and the games played in the Arena League between 2000 and 2004.

The results showed that the over in the totals markets is overbet. In addition, regression results showed that betting the under for totals of "110 or more" (62.9% winning probability with significance at 5 percent), "108 or more" (63.1% winning probability with significance at 10 percent) and "104 or more" (59.4 winning probability with significance at 5 percent) generates statically significant profitable returns.

In a study developed by Gray and his colleagues (2005), the authors tested the hypothesis of market efficiency in the Australian Rugby League (ARL) betting market. The sample included all games of this league between 1998 and 2002, for a total of 988 games of the regular season. In this study, both a naïve and a probit model was implemented to forecast game outcomes. The results showed an underestimation of the home-ground advantage suggesting statistical inefficiency in ARL betting market. Based on these results, the authors concluded that both naïve and probit models could generate profits: betting on home underdogs makes a return of 21% over a season (naïve model) and betting with a more sophisticated strategy (probit model) generates a return around 37% over a season.

Keeping in mind that many of the studies carried out in sports betting markets aim to get important insights about bettors' behavior that can serve as a fitting analog for financial markets, Borghesi (2007) found it surprising that such an important factor had received almost no interest in the literature, at the date: the impact of weather in the game outcome. In fact, evidence suggests that game day temperature highly influences the performance of players due to different physiological responses to cold and heat

(Taylor and Cotter, 2006). Thus, the author started from the idea that the performance of players decreases when they play with temperatures they are used to. Home team players are training in similar weather conditions to those on game days and as such, their bodies are well acclimatized. In turn, visiting players, traveling from places with very different temperatures may face greater difficulties. Using a dataset of 5748 NFL games played between the 1981 and 2004 seasons, and collecting the daily temperatures during that period from National Climatic Data Center, the author proposed to study whether this factor is reflected in the betting lines or if there is a market forecast error. The results showed that, on average, the market predicted home teams to win with an associated market forecast error of -0.34 points, which is not significantly less than zero ($p=0.473$). However, when the sample is divided into quartiles, results showed that bets on home team on the coldest games won at a rate of 54.09% which is statistically greater than 50% ($p=0.0015$), the percentage needed to provide evidence that this betting market is inefficient.

Another study developed by Vlastakis et al. (2009) proposed to explore the predictability of football results based on the odds posted at different bookmakers. The aims of this study were to identify possible arbitrage opportunities (free risk betting with positive return) and implement some betting strategies to test the hypothesis of efficient markets. The dataset used in this study was obtained during the period 2002-2004, and the odds were collected from five different bookmakers (Bet 365, Internet1x2, Interwetten, Sportingbet and William Hill). The sample contained a total of 12841 football matches, covering 26 countries, making a total of 55977 odds from online bookmakers and 28092 odds from fixed-odds bookmakers. Before analyzing the results of this study, it makes sense to clarify some previous concepts.

Assuming that the odds of an outcome represent the true probability of that outcome to happen, it is understandable that betting on all possible outcomes, with the total stake distributed proportionately according to the odds of each possible outcome, means no profit or loss for both the bettor and the bookmaker (Vlastakis et al., 2009). However, the odds set by bookmakers are slightly lower than the "fair odd" so that these entities can obtain a positive margin. In this scenario, it is expected that an individual who bet on all possible outcomes, will have a loss corresponding to the positive margin of bookmakers (Dixon and Pope, 2004).

The occurrence of arbitrage opportunities is due to different bookmakers offer different odds for the same event (Pope and Peel, 1989; Haush and Ziemba, 1990). The purpose of arbitrage is to take advantage of these differences, settling combined bets in different bookmakers, betting on all possible outcomes but choosing, for each result, the bookmaker offering the highest odds. Arbitrage is achieved when, in this scenario, the payoff for the winning bet is greater than the total invested (Paton and Williams, 2005).

Back to the study of Vlastakis and his colleagues, the results do not support the hypothesis of efficient markets. In the sample, they were found 63 arbitrage opportunities (1 in 200 matches) where more than half of the observations returned more than 12%, with a maximum yield of 200%. The average return of the arbitrages observed was 21.78%.

In the same year, Spann and Skiera (2009), compared the forecast accuracy of three methods: prediction markets, tipsters, and betting odds. The objective of this study was to determine which of the three methods is the most accurate and if it is possible to have profit consistency based on these methods performances. For this purpose, results of the German premier football league soccer games between the seasons 1999-2000 and 2001-2002 were collected, for a total of 837 games and then proceeded to the collection of stock prices of a prediction market, the tipster's predictions and the betting odds of the largest state-owned bookmaker. After analyzing the results of each forecasting method and after comparing the forecast accuracy between them, the authors concluded that prediction markets and the betting odds seem to have good forecast accuracy, in contrast with tipster's predictions that showed a poor performance. However, neither method can formulate a strategy that could yield profits with long term consistency because of the fees charged to bettors, showing that the studied betting market is efficient.

However, Direr (2013) confirmed the presence of market inefficiencies in soccer betting markets. The author analyzed a dataset of 79446 football matches, played in national leagues of 11 European countries between 2000 and 2011, and showed that picking the shortest odds systematically, delivers an annualized return of 104%. These findings also showed the presence of the favorite-longshot bias, once lower odds (associated with bets on favorites) provided higher rates of return.

Nichols (2014) noticed that, during the 2008 National Football League (NFL) season, teams from west coast always failed to win when they were visiting teams from east coast until the 13th week of the competition. So, the author proposed to study the impact of traveling (crossing time zones) on the outcome of games and to what extent is that the sports betting markets incorporate this information. Thus, games in NFL between 1981 and 2004 were analyzed for a total of 5453 games. The results showed that traveling has a significant impact on game outcomes, once home teams are more likely to win. Setting the traveling miles of visitor team to 991 (the average), the probability of a home team win the game against a traveling team is 69,3% when visitor travels east to west and 68,4% when the visitor goes west to east. The second part of this study was to assess if this information is fully considered in betting markets. The author findings suggest that that bettors tend to underestimate the score of home teams when playing against travelling teams but, using a model developed in this study to evaluate this fact, it is not possible to formulate a statistically significant winning betting strategy, once that model produced 5300 bets, of which 52.79% are winners, which is not statistically greater than the 52.38%, the required percentage to beat the studied market.

In a study developed by Croxson and Reade (2014) to test the hypothesis of efficient markets, the authors analyzed the high-frequency transactions in 1206 football games markets. The dataset was obtained from Betfair betting exchange. Basing this study on the appearance of a goal - the new major in a football match - the authors sought to determine whether market prices responded immediately and precisely to the occurrence of a goal. The author was unable to reject the hypothesis of market efficiency, once their regression tests showed that the market update efficiently the prices after the occurrence of a goal.

Hwang et al. (2015) analyzed the entire dataset of Volleyball Special Double – the only legalized sports betting market in Korea – between 2008 and 2012 with a total of 389 betting rounds during that period. Once each betting round comprises two matches and each match can have six different results, the total sample was composed by 504144 possible outcomes it was analyzed each potential winning payout associated with each outcome. The aims of this study were to understand if there is any biased bettor's behavior related to the extremeness aversion effect, already documented (Chernev, 2004), and see if this can be translated into profitable betting strategies. According to the author, the extremeness aversion effect, is based on the fact that people tend to avoid

choices that lie at the extremes and that seems to occur also with people while betting. In fact, the authors found that participants under betted extreme decision outcomes and this bias is substantial enough to cause market inefficiency and a chance to generate profits which averaged 45.07% return during the sample period.

Another study developed by Lobão and Rola (2015), showed evidence of inefficiencies at the biggest tennis circuit - the Association of Tennis Professionals (ATP) circuit. The aim of this study was to verify if the potential winning payout offered before the start of the match are generally good predictors of the outcome of the match, corroborating the efficiency of this market, and also to test if the market adequately incorporates the information about the key moments during the game of tennis (occurrence of breakpoints and set winnings). For this purpose, it was constructed a database containing 1910 observations of prices for 203 tennis matches played between October 2012 and March 2013 on the ATP circuit, and the data was collected from the Betfair betting exchange. The authors concluded that the market is efficient regarding the price of the assets before the start of the game. However, the overall result indicates that the individuals tend to overreact to events for the favorite player, leading them to overestimate the probability of victory of the favorite player in these conditions. That is, the strategy of betting against the favorite player when he gets a break, two breaks, win a set or accumulate a set and a break generates a statistically significant positive return (58.08%, 26.46%, 31.92% and 48.68%, respectively).

Also Woodland and Woodland (2015) tried to understand the market behavior regarding its efficiency. In this sense, they examined the “season wins total over/under” betting market in the National Basketball Association (NBA). Data were obtained from the ten seasons comprised between 2003 and 2013, with a total of 298 lines examined. The “season wins total over/under market” is related with the number of winning matches of a team during a season. Supposing that a bookmaker posts a wins total line of 54 for LA Lakers, the over bet will be won if the team wins at least 55 games during the season and the under bet will be won if the team win at most 53 games. If the team wins 54 games, the bet is returned. The results showed that market inefficiencies exist: betting the under for all teams with a winning record in the previous season provides an average return of 11.4%. According to the authors, that happened for two main reasons: first, because bettors tend to prefer over bets, which is explained by the fact that the entertainment of this game is provided by scoring points and also because is very

common to bet in preferred teams. Second, because bettors have the tendency to overreact to the most recent results history and they fail the assessment of teams' strengths and weaknesses.

3.4 The most recent evidence (2016)

This year, few studies have been done on this topic. In fact, there are only two studies, developed by authors already renowned in this field.

As previously seen, the "season wins total" market showed some evidence of inefficiencies because bettors tend to overvalue the team's performances in the previous seasons when predicting the future outcomes. These findings are in line with Tversky and Kahnemann (1974) that have argued that individuals often make their decisions based on the heuristics, that is, their decisions are influenced by past information and previous experiences. To test if this bias exists in others sports, Woodland and Woodland (2016) analyzed eight seasons in MLB from 2006 to 2013, with a dataset consisted of 237 observation available for analysis. Based on the assumption that teams with high winning records in the previous season are overvalued, the authors tested the strategy of betting the under on teams with these records. Supposedly, this overvaluation should raise the odds for this outcome to a value quite bigger than the odd that reflects the real probability of that outcome. In fact, results showed that the percentage of bets won in the different seasons ranged from 59% to 62%, yielding an average return from 12.3% to 18.9% (p-value ranged from 0.027 and 0.203). The authors state that this inefficiency, particularly in this market, is difficult to explain, but they speculate that bettors don't want to have their money tied up during a whole season, even knowing that the bet is attractive.

Also this year, Albinzano et al. (2016) studied the favorite-longshot bias, one of the most widely studied topics of research in the sports betting markets. As previously seen, this bias consists on the tendency for the expected profits to bets placed at shorter odds exceed the returns generated on bets placed at higher odds. However, this study contributed with new evidence to the existing literature. Until then, the favorite-longshot bias had been studied with datasets extracted from bookmaker's activity, and there was no research on this bias in betting exchanges. In fact, Lahvicka (2014) argued that bookmaker's actions with odd adjustments are the source of this bias and, under this perspective, favorite-longshot bias shouldn't occur in betting exchanges once the

odds are settled and adjusted by their participants and not by bookmakers. The dataset analyzed in this study consisted of 28595 professional tennis matches played between 2004 and 2013. To test the presence of favorite-longshot bias, betting odds were categorized (value-weighted, equal-weighted and high-volume odds) and then differences between the outcome of an event and its implied probability were calculated. The results confirmed the presence of favorite-longshot bias, thus contradicting previous findings of Lahvicka (2014).

4 Entrepreneurship and the entrepreneur profile

Since the last few years to date, the phenomenon of entrepreneurship deserved the attention of several prominent academics, policymakers and business stakeholders across a broad spectrum of academic fields. (Kaufmann and Dant, 1999).

In the literature, there are several definitions of entrepreneurship (Raimi, 2015) and due to this huge evidence, it's even possible to find contradictory views. (Kaufmann and Dant, 1999). As Kaufmann and Dant (1999: 6) underlined about this contradiction, "this is not surprising. Entrepreneurship is a multifaceted phenomenon and cuts across many disciplinary boundaries (e.g., management, economics, sociology, marketing, finance, history, psychology, social anthropology, etc.)." As a result, researchers from each field mentioned above, adopted different approaches and presented several theories and perspectives (Low and MacMillan, 1988).

Timmons and Spinelli (2007:101) argue that "entrepreneurship is a way of thinking, reasoning, and acting that is opportunity obsessed, holistic in approach, and leadership balanced for the purpose of value creation and capture". They also state that this process allows "...the creation, enhancement, realization, and renewal of value..." not only for the entrepreneurs and their businesses but also for the other players involved. Hessels et al. (2008), define entrepreneurship as a leverage of economic growth and states that different entrepreneurial profiles contribute differently to that growth. This idea was shared by Brixiova (2014:440) that considered entrepreneurship as a "...key driver of economic development through fostering growth, job creation, technology adoption and, innovation..." From another point of view, Ahmad and Seymour (2008:5), argued that "the concept of entrepreneurship refers to enterprising individuals who display the readiness to take risks with new or innovative ideas to generate new products or services."

There is a wide range of articles in the literature studying how personal characteristics, social condition, the influence of peers and the cognitive structure control the attitude and decision of an individual to run entrepreneurial activities (Carter et al., 2000; Lichtenstein et al., 2007; Bezzina, 2010). According to Gatewood et al. (1995), the cognitive structure and the way of thinking of an individual may have a significant influence on how an entrepreneurial attitude persists when difficulties arise in the

development of a business. Carter et al. (2000), systematized the reasons why entrepreneurs decide to run a business in six categories: innovation, independence, self-realization, recognition, roles and financial success.

Despite having not yet found the perfect profile to be an entrepreneur, there seems to be some characteristics and attitudes that consistently are revealed when analyzing an entrepreneurial profile: need for achievement, the locus of control, tolerance ambiguity, self-confidence, creativity/innovation, risk-taking propensity and self-sufficiency/freedom (Bezzina, 2010). Furthermore, according to the author, these characteristics are widely discussed in the literature and to address the research question of this study properly, they will be discussed below:

4.1 Need for achievement

The theory of McClelland (1961) about the need for achievement is one of the most described principles in entrepreneurship field. According to this theory, the need for achievement is the driving force behind the excellence and success struggled by people with this characteristic. (Sagie and Elizur, 1999). People who have the need for achievement, seek success, putting themselves highly ambitious, but achievable goals and try to reach them with their own resources and efforts (Bezzina, 2010). The author also states that people with need of achievement tend to prefer entrepreneurial jobs rather than other because they prefer to work alone and independently from others roles. In fact, Steward et al. (2003) concluded that high achievement motivation is an important characteristic of the entrepreneurship once they found out that entrepreneurs have the higher need for achievement than non-entrepreneurs. Furthermore, need for achievement appear to have a stronger relation with entrepreneurship than others characteristics of the entrepreneurial profile mentioned in the literature (Gürol and Atsan, 2006).

4.2 Locus of control

According to Leone and Burns (2000), the locus of control is a personality trait that is related to the expectation of someone to monitor and influence the events of life. Rotter (1966), argued that this locus of control can be internal or external: people with internal locus of control believe that they have direct control over their life and all the events and results are the direct consequence of their decisions. On the other hand, people

with external locus of control are convinced that the outcomes of their life's events are a result of factors as luck, chance or fate.

According to some authors, entrepreneurs have an internal locus of control, and they believe that they actually can control and influence their destiny (Koh, 1996; Utsch and Atsan, 2006; Hansemark, 1998; Bezzina, 2010). Additionally, there are studies reporting that this characteristic is distinctive of entrepreneurs and non-entrepreneurs (Mueller and Thomas, 2000) as well of entrepreneurially inclined people and non-entrepreneurially willing people (Gürol and Atsan, 2006).

4.3 Tolerance towards ambiguity

Theo and Foo (1997) defined tolerance towards ambiguity as for the ability to respond positively to ambiguous situations. Furthermore, this type of people tends to comfortably handle these situations, considering that are attractive opportunity instead of uncomfortable and threatening (Bezzina, 2010). This idea is shared by Shane et al. (2003) which argues that this characteristic is vital for entrepreneurs since, in general, business in early stages are subject to endless and unpredictable situations. In fact, entrepreneurs and people with entrepreneurial goals seem to have a significantly greater capacity to face ambiguous situations and explore them with positive outcomes to their businesses (Koh, 1996).

4.4 Self-confidence

Entrepreneurs are usually described as having a lot of confidence in themselves (Gürol and Atsan, 2006). In fact, self-confidence is crucial in an entrepreneurial environment since creating a business and overcome the many barriers adjacent to this process is not easy and requires a lot of self-confidence to not give up (Bezzina, 2010). To support this theory, Pintrich (2003) stated that people who have greater levels of confidence, have more motivation and persistence than individuals who do not rely too much on themselves. Studies show that, in fact, entrepreneurially inclined people have higher levels of self-confidence than others (Koh, 1996; Baum and Locke, 2004; Gürol and Atsan, 2006; Bezzina, 2010).

4.5 Creativity/innovation

It is widely suggested in the literature that innovativeness is one of the behaviors that best characterizes the personality of an entrepreneur (Gürol and Atsan, 2006; Entrialgo et al., 2000). As Bezzina (2010: 296) underlined, “entrepreneurs are generally characterized as individuals who are full of creative and innovative ideas and are also able to merge these ideas with the resources available to generate additional value”. Entrepreneurs always see market changes as new opportunities (Cromie, 2000), and this characteristic can differentiate entrepreneurs from people who don’t have this mindset (Stewart et al., 2003). In fact, there are already some studies, showing that people with entrepreneurial intentions are much more innovative than people who don’t have this personality (Koh, 1996; Stewart et al., 2003; Gürol and Atsan, 2006; Bezzina, 2010).

4.6 Risk-taking propensity

It is understood as risk-taking propensity as the propensity of an individual to take or avoid risk when faced with risky situations (Gürol and Atsan, 2006). Historically, entrepreneurship is strongly associated with risk acceptance not only regarding profit and loss (Entrialgo et al., 2000), but also about risk related to well-being, career development, family stability or emotional state (Littunen, 2000). This characteristic is also well explored in previous studies and the authors concluded that entrepreneurs are more willing to take risks, when compared with others, even though these risks are carefully measured and followed with a minimizing risk strategy (Theo and Foo, 1997; Cromie, 2000; Thomas and Mueller, 2000; Bezzina, 2010).

4.7 Self-sufficiency/freedom

Bezzina (2010: 297) defined self-sufficient people as “independent persons who want to be their own boss, who want to be able to make their own choices and want to set their own constraints”. This means that these people hone up by having responsibility for their lives instead of living off the efforts of others (Shane et al., 2003). The author also states that this higher necessity of independence seems to be present more frequently in entrepreneurially oriented people and so, the self-sufficiency level is significantly higher in this people than the general population.

The contribution of entrepreneurship to the development and growth of global and local economies is widely evidenced in the literature (Raimi, 2015). As stated by Gaspar (2009), entrepreneurship is a major source of job creation, and it is one of the main drivers of innovation and represents a career option to a significant portion of the workforce. However, as previously seen, there are some personality characteristics which enhance the ability of entrepreneurs to run entrepreneurial activities and consequently raise their success rates. There is a very wide range where entrepreneurship can be developed. It cuts across all academic fields or labor sectors and sports betting markets are not an exception: how bookmakers manage their businesses, how sports traders face the daily pressure of working in an environment of uncertainty, how third parties (advertising companies, advising services, forecasting entities, etc.) fit on the market and how all these agents relate among themselves are issues that can bring interesting inputs to the literature about entrepreneurship, if adequately addressed.

5 Methodological considerations

To synthesize data across studies analyzed in this chronological review, a meta-analysis was made. Meta-analytic techniques were applied in this study to assess if market efficiency hypothesis can be rejected.

Since it is a chronological review, bibliographic searches were conducted on all studies without restriction of the journal and publication year. Only studies written in English were selected.

To find relevant articles, we performed an online search on the Scopus database, with the keywords “information efficiency” and “betting markets”. This search was conducted several times between April and June 2016 to get the broadest cross-section of articles.

From the results generated, studies that didn’t address specifically the market efficiency were excluded, such as studies confined to betting behavior, book chapters, and conference papers.

The selected studies were reviewed for information on the following characteristics: author(s) and year of publication, sample size, market considered and the presence of market inefficiencies. All required data were available in the all 28 articles identified as validity studies of sports betting market efficiency.

6 Main results

The following tables show an overview of the literature reviewed. *Table 2* demonstrates the evidence of market efficiency. The results suggesting market inefficiencies are reported in *Table 3*. Both tables are organized according to the market studied, sample characteristics, results and author(s).

Table 2 Characteristics of the included studies in meta-analysis with evidence of market efficiency.

Study	Sample characteristics	Results	Betting market
Woodland and Woodland (1994)	24603 games were analyzed, for the 1979 to 1989 seasons	Bettors tend to overbet the favorite, but there is no evidence of inefficiencies in the market since tests for individual betting lines showed no significant differences between objective and subjective win probabilities (F-statistic of 0.474 and corresponding probability value of 0.628)	Major League Baseball (MLB)
Dare and MacDonald (1996)	3164 NFL games played between 1980 and 1993; 6685 college football games played between 1981 and 1993	The results showed no evidence of market inefficiencies. Also, the authors revealed that previous researchers could have biases in their conclusions.	National Football League (NFL) and College Football
Woodland and Woodland (2003)	20829 games during from 1990 to 1999 seasons. When combined with Woodland and Woodland (1994), the sample totals 44675 games between 1979 and 1999.	Bettors still overbet favorite teams and underbet underdog teams. However, this bias does not represent a market inefficiency: the p-value decreased from 0.097 (in the original study) to 0.037, but efficiency is only rejected with a p-value of 0.002, according to the regression analysis.	Major League Baseball (MLB)
Dare and Holland (2004)	All games from 1995 to 1999 NFL seasons	Presence of the bias favoring home underdog teams remains, but with no strong enough evidence to reject the hypothesis of market efficiency. The potential profits generated by bias favoring home underdog teams seem to be too small to be explored, in contrast with Gray and Gray (1997) previous findings.	National Football League (NFL)
Spann and Skiera (2009)	837 games from 1999-2000 to 2001-2002 seasons	Prediction markets and betting odds seem to have a good forecast accuracy and no evidence of long-term profit consistency was found.	German Premier Football League
Nichols (2014)	5453 games during the	Bettors underestimate the score of	National

	regular season between 1991 and 2004	home teams when playing against traveling teams, but it can't be considered a market inefficiency: the model produced 5300 bets, of which 52.79% are winning bets, which is not statistically greater than the required percentage to beat the studied market.	Football League (NFL)
Croxson and Reade (2014)	High-frequency transactions in 1206 football games, obtained from Betfair	The author were unable to reject the hypothesis of market efficiency, once their regression tests showed that the market update efficiently the prices after the occurrence of a goal.	Professional soccer games

Table 3 Characteristics of the included studies in meta-analysis with evidence of market inefficiencies.

Study	Sample characteristics	Results	Betting market
Ali (1977)	20247 horse races from 1970 to 1974 seasons.	The difference between objective and subjective probabilities are statistically significant in groups 1, 4, 5, 6, 7 and 8 (-10.29, 3.45, 3.49, 3.01, 5.80 and 6.20 respectively). Horses with a high objective probability of winning are underbet and horses with a low objective probability of winning are overbet.	Horse Racing (various racetracks)
Hausch et al. (1981)	627 races in the 1973-1974 winter season at Santa Anita Racetrack; 1065 races in the 1978 summer season at Exhibition Park.	The implemented model produced a return of 22.9%. Reliability of results was tested by an anonymous referee and significant inefficiencies in the "place" and "show" markets were confirmed.	Horse Racing (Exhibition Park and Santa Anita)
Asch et al. (1982)	729 races and 5805 horses during the 1978 racing season	As found by Ali (1977), the betting odds have a good forecasting accuracy. However, evidence of market inefficiency was found in three groups: differences between objective and subjective probabilities are statistically significant at 0.05 level in first favorites (-2.119), third favorites (-1.972) and ninth favorites (2.095). Again, the favorites are underbet, and the underdogs tend to be overbet.	Atlantic City Race Course
Golec and Tamarkin (1991)	Regular season and playoffs games from 1973 to 1987, making a total of 3244 NFL games and 6514 college league games, which were	Bettors underestimated the power of home and underdog teams systematically during the mentioned period. Betting the underdog teams in the NFL is the most profitable strategy, with a statistically significant winning	National Football League (NFL) and College League

	analyzed separately.	percentage of 55.6%, however the profit potential depends on the transaction costs.	
Gray and Gray (1997)	4219 games from 1976 to 1994, covering the all 28 NFL teams	People tend to underestimate home underdog teams. Betting just on the teams predicted by the probit model generated a 6.93% profit, with statistical significance ($p = 0.013$).	National Football League (NFL)
Paul and Weinbach (2005)	NCAA games played between 1999 and 2003 and the games played in the Arena League between 2000 and 2004.	Betting the under for totals of "110 or more" (62.9% winning probability with significance at 5 percent), "108 or more" (63.1% winning probability with significance at 10 percent) and "104 or more" (59.4 winning probability with significance at 5 percent) generates statically significant profitable returns.	NCAA college football and the Arena Football League
Gray et al. (2005)	988 games of the regular season between 1998 and 2002	Both naïve and probit models can generate profits: betting on home underdogs generates a return of 21% over a season (naïve model) and betting with a more sophisticated strategy (probit model) generates a return around 37% over a season.	Australian Rugby League (ARL)
Borghesi (2007)	5748 NFL games played between the 1981 and 2004 seasons, daily temperatures during that period collected from National Climactic Data Center	On aggregate, the market predicted home teams to win with an associated market forecast error of -0.34 points, which is not significantly less than zero ($p=0.473$). However, when the sample is divided into quartiles, bets on home team on the coldest games won at a rate of 54.09% which is statistically greater than 50% ($p=0.0015$), the percentage needed to provide evidence that this betting market is inefficient.	National Football League (NFL)
Vlastakis et al. (2009)	12841 soccer matches, covering 26 countries, during the period 2002-2004	They were found 63 arbitrage opportunities (1 in 200 matches) where more than half of the observations returned more than 12%, with a maximum yield of 200%. The average return of the arbitrages observed was 21.78%.	Professional soccer games
Direr (2013)	79446 soccer matches, played in national leagues of 11 European countries between 2000 and 2011	Picking systematically the shortest odds, delivers an annualized return of 104%. These findings also showed the presence of the favorite-longshot bias.	Professional soccer games
Woodland and Woodland (2015)	298 betting lines examined from 2003 to 2013 seasons	Betting the under for all teams with a winning record in the previous season provides an average return of 11.4%.	National Basketball Association

(NBA)			
Lobão and Rola (2015)	1910 observations of prices for 203 tennis matches played between October 2012 and March 2013	Bettors overreact to events in favor of favorite player, leading them to overestimate the probability of victory of the favorite player in these conditions. The strategy of betting against the favorite player when he gets a break, two breaks, win a set or accumulate a set and a break generates a statistically significant positive return (58.08%, 26.46%, 31.92% and 48.68%, respectively).	Association of Tennis Professionals (ATP)
Hwang et al. (2015)	504144 betting odds belonging to 389 betting rounds between 2008 and 2012.	Participants underbet extreme choice outcomes and this bias is large enough to cause market inefficiency and a chance to generate profits which averaged of 45.07% return during the sample period.	Volleyball Special Double (Korea)
Albinzano et al. (2016)	28595 matches played between 2004 and 2013	Presence of favorite-longshot bias.	Professional Tennis
Woodland and Woodland (2016)	237 observations from 2006 to 2013 seasons	The percentage of bets won in the different seasons ranged from 59% to 62%, yielding an average return from 12.3% to 18.9% (p-value ranged from 0.027 and 0.203).	Major League Baseball (MLB)

To aggregate the results of all studies, we conducted a simple meta-analysis where studies reporting market efficiency were categorized with the value “-1”, value “1” was attributed to studies showing evidence of market inefficiencies and studies with doubt on the findings, we assign the value “0”. A total of 279874 observations were included in the 28 studies.⁵ The meta-analysis consists of considering each study as a sample and, from all studies, verifying whether the evidence is towards efficiency (value “-1”) or inefficiency (value “1”). Thus, we built a statistical test with H1+: there is evidence of market inefficiency; H1-: there is evidence of market efficiency; H0: there is no evidence of neither market efficiency nor market inefficiency.

Since, statistically, studies with bigger samples contain more information, we considered three weighting scenarios: at first, the weight was the total number of cases considered in this work; in second, the weight was the square root of the number of

⁵ The studies presented in Table 1 were included in the meta-analysis.

cases; third, the weight was the simple mean. In the statistical test, we assumed that all studies use independent samples (i.e., the correlation between the samples used in the various studies is zero) which is a conservative assumption since the correlation, if any, will always be positive.

Table 4 presents summary statistics about the overall studies regarding the market efficiency issue. The results of this meta-analysis show that although there is a tendency to the presence of some forms of market inefficiencies, there is no sufficiently statistical evidence to reinforce neither market efficiency nor market inefficiency hypothesis, whatever the adopted weighting variable (mean values between 0.286 and 0.373 with p-value higher than 30%).

Table 4 Summary statistics

Weighting variable	“Cases” (n)	Mean (m)	Standard deviation (SD)	t- student	p-value (p)
Number of cases as weight	279874	0.373	0.868	0.43	0.33
Square root of the number of cases as weight	2304	0.262	0.865	0.09	0.47
Simple mean	28	0.286	0.854	0.23	0.41

7 Discussion and conclusions

It is undeniable that sports betting markets are nowadays an important sector of the world economy. The exponential growth of this market, which is increasingly attracting more and more investors and participants around the world, drew the attention of the scientific community that put emphasis on this issue in the last decade. First, because of the way these markets can provide valuable information to financial markets, but also due to the increasing observations of inefficiencies in some markets that raise important questions regarding the transformation of these biases in betting strategies to generate consistent profits and create business opportunities.

Although the exponential growth of online sports betting has been observed in a still recent past, the efficiency of sports betting markets are an old topic of research, and since the early beginnings, it gathers no consensus. The first studies done under a natural environment were developed in horse racing and immediately began to emerge results indicating that these markets had some inefficiencies that, when properly harnessed, could generate consistent profits. However, it did not take too long to appear new studies denying the conclusions of previous studies, arguing that many authors have adopted methodologies and models with statistical limitations and thus causing biased results.

With the development of new betting models and the improvement of previously existing methods, research on sports betting markets naturally widened to other markets beyond horse racing. Studies developed in sports markets such as baseball (author), basketball (author) and others have shown that some of the inefficiencies that were observed in horses markets persisted in these sports. Based on these observations, studies of efficiency of sports betting markets increased exponentially and focused primarily on the study of betting behavior, on how bets settled influenced the market and how bookmakers were managing their betting lines. Again, the controversy among the scientific community has always accompanied the research evolution in these markets, and the presence of market inefficiencies was fueling this debate. Furthermore, due to the many similarities between sports betting markets and financial markets, the scientific community intensified the research in this field, since these markets provided valuable insights for the understanding of financial markets.

The emergence of sports betting exchanges radically changed the course of research in market efficiency. The dynamics of a betting exchange compared with the traditional model of a bookmaker opened doors for testing new approaches to efficiency. Through a betting exchange, it became possible for individuals to bet among themselves. Thus, in a betting exchange, each participant analyses the available information about an event and individually contributes to his knowledge. The sports betting exchanges then represent the aggregation of the knowledge and information of its participants (Spann and Skiera, 2003). The bettor's active role in price formation is the big novelty because until then, this process had been the exclusive preserve of bookmakers (Mainelli and Dibb, 2004).

Consequently, nowadays, research on market efficiency covers a very wide range of sports that, in addition to the most popular ones (horse racing, soccer, and basketball) also includes more exotic sports like volleyball, golf, and rugby.

Based on this literature review, central questions in this research field can arise and provide big enough space for discussion and reflection of several issues: how should be explored market inefficiencies? Are these inefficiencies robust enough to offer opportunities for consistent profits? Does it make sense to put up entrepreneurship in this equation? Are sports betting markets an excellent environment to study personality characteristics required to an entrepreneur, given the similarities of the circumstances in which bettors and entrepreneurs operate?

Concerning the market inefficiencies, there is a broad range of biases observed in this literature review. However, the favorite-longshot bias is naturally highlighted due to the high frequency with which it is observed, and for that reason, it deserves an emphasis in this discussion.

The favorite-longshot bias is the most well-investigated bias in the literature. In fact, the first researches in this field were made precisely to test Preston and Baratta (1948) laboratory findings that showed that, in situations of uncertainty, the events most likely to occur were underbet and low probability events were overbet. The results of those studies (Griffith, 1949; McClothlin, 1956; Fabricant, 1965; Weitzman, 1965; Seligman, 1975; Snyder, 1978) lead to a common conclusion: there is a tendency for bettors to underbet the favorites and overbet the longshots. More recently, evidence shows that

this bias persists in different sports, evidencing that bettors obtain higher returns when betting on favorites and lower returns when betting on longshots (Albinzano et al., 2016). Several authors have speculated on the reasons for this bias is so common. Snowberg and Wolfers (2010) suggests that the risk preferences of bettors can be the basis for some of the observed inefficiencies. According to the authors, many bettors prefer to bet on results with very high payoffs even though knowing that the probability of winning is slight. This demand for major prizes seems to make the emotional component overlaps the rational behavior. Ali (1977) also agree with this argument, and complements this perspective, speculating that there is a tendency for a bettor prefer increasingly higher betting odds (and therefore more likely to be lost) as they lose the previous bets, in a very emotional attempt to recoup their losses with a last bet.

In addition to the favorite-longshot bias, the other observed biases also deserve some considerations. On the assumption that the inefficiencies in the market arise when information about an event is not fully reflected in its value (Gray et al, 2005), it is interesting to note that there is a very diverse range of factors that favor this type of inefficiencies, such as the overvaluation of the performance of the teams in previous games (Woodland and Woodland, 2015), the home field advantage (Golec and Tamarkin, 1991), the effect of jet lag in teams traveling long distances (Nichols, 2014) and even to the temperature that is felt on game days (Borghesi, 2007). Given that these biases are a manifestation of bettor's misperceptions about the real probabilities of an outcome, and that misperceptions are often caused by irrational behaviors ("risk loving", team preferences, etc), this work can bring useful information to bookmakers in the sense that they can develop innovative products that meet the bettor's preferences.

Even though entrepreneurship is widely addressed in the literature, the link between sports betting markets and entrepreneurial activities are yet understudied. There is a very wide range of academic fields and labor sectors where entrepreneurship can be developed and sports betting markets are not an exception.

According to Gatewood et al. (1995), the cognitive structure and the way of thinking of an individual may have a significant influence on how an entrepreneurial attitude persists when difficulties arise in the development of a business. And in fact, it is interesting to check that the skills required to the agents operating in sports betting markets (whether bettors, traders, bookmaker's managing teams, and third parties) are

quite coincident with the cognitive profile that characterizes a successful entrepreneur: need for achievement, locus of control, tolerance ambiguity, self-confidence, creativity/innovation, risk-taking propensity and self-sufficiency/freedom (Bezzina, 2010).

The aim of the present dissertation was to assess whether sports betting markets was perceived as an important source of entrepreneurship and what kind of paths should be drawn to run entrepreneurial activities in this sector.

This literature review shows us that the existence or not of market inefficiencies sufficiently robust enough to develop profitable betting strategies is still a very controversial topic. Apart from that, the present literature review shows that the cognitive profile of an entrepreneur and the required attitudes towards an entrepreneurial environment are quite similar to the ones required of agents operating in sports betting markets (bettors, bookmakers, third parties). Since there is little literature that addresses the potential development of entrepreneurship in sports betting markets, this work can bring significant insights to the development of this research field, to all the agents involved in these markets. For future research, it would be interesting to understand if sports betting markets can represent a proper training environment for economic operators in financial markets, due to the similarities between both markets. Similar to the study conducted by Bezzina (2010) with entrepreneurs, it would also be interesting to evaluate if agents operating in sports betting markets have in fact the same cognitive profile and attitudes as entrepreneurs.

8 References

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